DOCKET NO.: KAWA-1003US   **PATENT**
Application No.: 11/575,909
Response to the Notice of Allowance and Fees Due dated December 23, 2008
Amendment dated March 4, 2009
Page 2

Amendments to the Specification

In the paragraph starting on page 3, starting with "In order to achieve the above object,", please amend as the following:

In order to achieve the above object, the method for calculating charged rate of a secondary battery according to the first aspect of the present invention is intended to calculate charged rate of a secondary battery which ~~supplies~~ is adapted to supply electric power to loads to a load, and comprises the steps of: providing a time function for the open circuit voltage of the secondary battery as a function of time with its coefficients undetermined; measuring voltages samples of the open circuit voltage of the secondary battery at a plurality of different time points within a predetermined period of time after termination of charge or discharge to obtain a plural measured voltages samples along time axis; ~~sequentially calculating~~ using the plural measured voltages samples to determine the coefficients of ~~a quadric or more exponential damping function which approximates time characteristic of an open circuit voltage of the secondary battery~~ the time function to thereby determine the time function; calculating a convergent value of the open circuit voltage of the secondary battery based on ~~at least~~ the ~~coefficients~~ determined time function; and calculating the charged rate based on the convergent value of the open circuit voltage: wherein the step of providing the time function comprises providing a combination of at least two exponential decay functions in which the combination of N exponential decay functions, hereinafter referred to as multi-exponential decay function, where N is an integer of at least two is given by

$$Y = a1 \exp(-b1 \cdot X) + a2 \exp(-b2 \cdot X)$$
$$+ a3 \exp(-b3 \cdot X) + a4 \exp(-b4 \cdot X)$$
$$+ \cdots + an \exp(-bn \cdot X) + c$$

wherein (2N+1) coefficients a1 to an, b1 to bn and c are undetermined, Y denotes the open circuit voltage, and X denotes time; and

wherein the step of using the plural measured voltage samples comprises using the measured voltage samples to determine the (2N+1) coefficients to determine the multi-exponential decay function.

In the paragraph starting on page 4, starting with "In the method for calculating charged rate of a secondary battery according to the second aspect of the present invention," please amend as the following:

In the method for calculating charged rate of a secondary battery according to the second aspect of the present invention, ~~the convergent value of the open circuit voltage is calculated with the use of the function obtained from the quadric or more exponential damping function by removing the predetermined terms depending on the standby time of voltage measurement.~~ wherein predetermined exponential decay terms included in the multi-exponential decay function are removed in correspondence to a standby time of measuring the plural measured voltage samples along the time axis to calculate the convergent value of the open circuit voltage of the secondary battery.

In the paragraph starting on page 4, starting with "In the method for calculating charged rate of a secondary battery according to the third aspect of the present invention," please amend as the following:

In the method for calculating charged rate of a secondary battery according to the third aspect of the present invention, wherein the ~~exponential damping~~ multi-exponential decay function is the function with time T as described below in the formula (1) which has five coefficients of A1, A2, A5, A6 and C:

$$F(T) = A1 \exp(A5 \cdot T) + A2 \exp(A6 \cdot T) + c \qquad (1)$$

wherein F(T) denotes the open circuit voltage.

In the paragraph starting on page 5, starting with "In the method for calculating charged rate of a secondary battery according to the fourth aspect of the present invention," please amend as the following:

In the method for calculating charged rate of a secondary battery according to the forth aspect of the present invention, wherein the ~~exponential damping~~ multi-exponential decay function is the function with time T as described below in the formula (2) which has the nine coefficients of A1 to A9:

$$F(T) = A1\exp(A5 \cdot T) + A2\exp(A6 \cdot T)$$
$$+ A3\exp(A7 \cdot T) + A4\exp(A8 \cdot T) + A9 \tag{2}$$

In the paragraph starting on page 6, starting with "In the method for calculating charged rate of a secondary battery according to the fifth aspect of the present invention," please amend as the following:

In the method for calculating charged rate of a secondary battery according to the fifth aspect of the present invention, the formula (3) mentioned below is used in place of the function F(T) of the formula (2) when the standby time of voltage measurement is more than or equal to the-a predetermined first time and less than a predetermined second time, the formula (4) mentioned below is used in place of the function F(T) of the formula (2) when the standby time of voltage measurement is more than or equal to the predetermined second time and less than a predetermined third time, and the formula (5) mentioned below is used in place of the function F(T) of the formula (2) when the standby time of voltage measurement is more than or equal to the predetermined third time:

$$F(T) = A2\exp(A6 \cdot T) + A3\exp(A7 \cdot T) + A4\exp(A8 \cdot T) + A9 \tag{3}$$

$$F(T) = A3\exp(A7 \cdot T) + A4\exp(A8 \cdot T) + A9 \tag{4}$$

$$F(T) = A4\exp(A8 \cdot T) + A9 \tag{5}$$

In the paragraph starting on page 7, starting with "An apparatus for calculating charged rate of a secondary battery according to the eighth aspect of the present invention," please amend as the following:

An apparatus for calculating charged rate of a secondary battery according to the eighth aspect of the present invention, which ~~calculates the charged rate of the secondary battery~~ is adapted to supply ~~at least~~ a load with electrical power, ~~comprises~~ comprising a voltage sensor to measure voltage samples indicative of an open circuit voltage of the secondary battery at a plurality of different time points within a predetermined period of time after termination of charging or discharging; a control ~~part~~ unit ~~to execute and control the computing process for~~

~~calculation of~~ receive the measured voltage samples from the voltage sensor to calculate the

charged rate; ~~and a storage part to store the voltage value output from the voltage sensor and the~~

~~datum required for the computing process on the control part;~~

~~wherein the control part receives the output from the voltage sensor once or more within a~~

~~predetermined period of time after termination of charge or discharge, stores the more than one~~

~~voltage measurement value into the storage part, recursively calculates with the more than one~~

~~voltage measurement value to be read from the storage part, determines the coefficients of a~~

~~quadric or more exponential damping function to approximate the time characteristic of the open~~

~~circuit voltage of the secondary battery, calculates a convergent value of the open circuit voltage~~

~~based on the determined coefficients, and executes to calculating the charged rate from the~~

~~convergent value~~

wherein the control unit comprises a providing means for providing a combination of at

least two exponential decay functions in which the combination of N exponential decay

functions, hereinafter referred to as multi-exponential decay function, where N is an integer of at

least two is given by

$$Y = a1 \exp(-b1 \cdot X) + a2 \exp(-b2 \cdot X)$$
$$+ a3 \exp(-b3 \cdot X) + a4 \exp(-b4 \cdot X)$$
$$+ \cdots + an \exp(-bn \cdot X) + c$$

wherein (2N+1) coefficients a1 to an, b1 to bn and c are undetermined, Y denotes the open

circuit voltage, and X denotes time;

a function determining means for using the measured voltage samples to determine the

coefficients of the multi-exponential decay function to thereby determine the multi-exponential

decay function; and

a charge determining means for calculating the charged rate of the secondary battery

using at least the determined multi-exponential decay function, the charge determining means

including means for determining a convergent value of the open circuit voltage using the

determined multi-exponential decay function, and for calculating the charge rate using the

determined convergent value of the open circuit voltage.

In the paragraph starting on page 8, starting with "An apparatus for calculating charged rate of a secondary battery according to the ninth aspect of the present invention," please amend as the following:

In the apparatus for calculating charged rate of a secondary battery according to the ninth aspect of the present invention, wherein the control unit further comprises means for simplifying the multi-exponential decay ~~the convergent value of the open circuit voltage of the secondary battery is calculated with the function obtained from the quadric or more exponential damping function~~ by removing ~~the~~ a predetermined term in the multi-exponential decay function depending on ~~the~~ a standby time of voltage measurement which is an elapsed time from termination of charge or discharge to starting to measure voltage, and means for applying the measured voltage samples to the simplified exponential decay function to determine its coefficients to determine the simplified exponential decay function in order that the convergent value of the open circuit voltage of the secondary battery may be calculated from the determined simplified exponential decay function.

In the paragraph starting on page 8, starting with "An apparatus for calculating charged rate of a secondary battery according to the tenth aspect of the present invention," please amend as the following:

In the apparatus for calculating charged rate of a secondary battery according to the tenth aspect of the present invention, ~~there are determined the five coefficients of A1, A2, A5, A6 and C of the exponential damping function with time T as described below in~~ wherein the multi-exponential decay function has five coefficients A1, A2, A5, A6 and C and is given by the formula (6)~~, and that the convergent value is calculated with the function~~:

$$F(T) = A1 \exp(A5 \cdot T) + A2 \exp(A6 \cdot T) + c \tag{6}$$

wherein T denotes time and F(T) denotes the open circuit voltage.

In the paragraph starting on page 9, starting with "In the apparatus for calculating charged rate of a secondary battery according to the eleventh aspect of the present invention," please amend as the following:

In the apparatus for calculating charged rate of a secondary battery according to the eleventh aspect of the present invention, ~~the exponential damping function with time T as described below in~~ the multi-exponential decay function has nine coefficients A1 to A9 and is given by the formula (7) ~~is used~~:

$$F(T) = A1 \exp(A5 \cdot T) + A2 \exp(A6 \cdot T)$$
$$+ A3 \exp(A7 \cdot T) + A4 \exp(A8 \cdot T) + A9 \qquad (7)$$

wherein T denotes time and F(T) denotes the open circuit voltage.

In the paragraph starting on page 9, starting with "In the apparatus for calculating charged rate of a secondary battery according to the twelfth aspect of the present invention," please amend as the following:

~~IN~~ In the apparatus for calculating charged rate of a secondary battery according to the twelfth aspect of the present invention, the formula (8) mentioned below is used in place of the function F(T) of the formula (7) when the standby time of voltage measurement, which is the time from termination of charge or discharge for the secondary battery to starting the voltage measurement, is more than or equal to ~~the~~ a predetermined first time and less than a predetermined second time , the formula (9) mentioned below is used in place of the function F(T) of the formula (7) when the standby time of voltage measurement is more than or equal to the predetermined second time and less than a predetermined third time, and the formula (10) mentioned below is used in place of the function F(T) of the formula (7) when the standby time of voltage measurement is more than or equal to the predetermined third time:

$$F(T) = A2 \exp(A6 \cdot T) + A3 \exp(A7 \cdot T) + A4 \exp(A8 \cdot T) + A9 \qquad (8)$$

$$F(T) = A3 \exp(A7 \cdot T) + A4 \exp(A8 \cdot T) + A9 \qquad (9)$$

$$F(T) = A4 \exp(A8 \cdot T) + A9 \qquad (10).$$

In the paragraph starting on page 11, starting with "The power supply system with secondary battery according to the fifteenth aspect of the present invention," please amend as the following:

The power supply system with secondary battery according to the fifteenth aspect of the present invention comprises the apparatus for of calculating charged rate of a secondary battery according to any one of the eighth through the thirteenth aspect of the present invention.